

INNOVATIVE SOLUTIONS for BARRIER COATINGS

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- **Worldwide Emulsions Partnership with Wacker-Chemie**
 - **Established 01 October 1998**
- **Worldwide Leader in VAE/EVCL Technology: Airflex[®]**
- **Global Production/Product Development Capability**

APP offers a wide range of chemistries for a wide range of markets & applications

Product Families

Vinyl Acetate Ethylene (VAE)
Ethylene Vinyl Chloride (EVCL)
Vinyl Acetate (PVAc)
Acrylic
Vinyl Acrylic
Styrene Acrylic
Other unique, specialty polymers

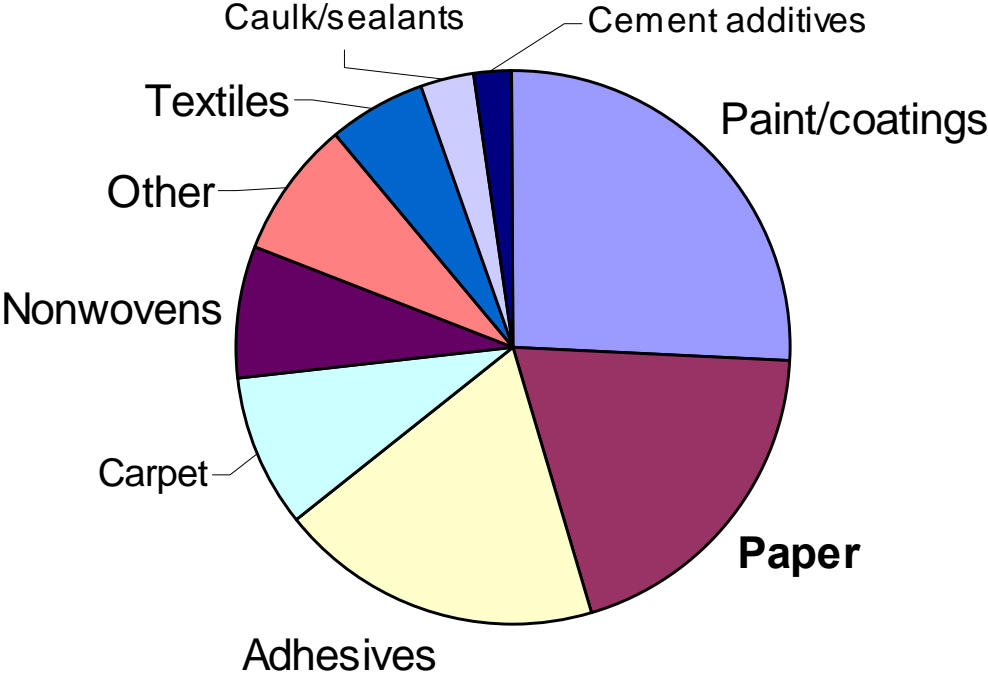
Major Markets

Adhesives
Building Products
Coatings
Nonwovens
Specialty Paper
Rugbacking
Textiles

APP Polymer Applications

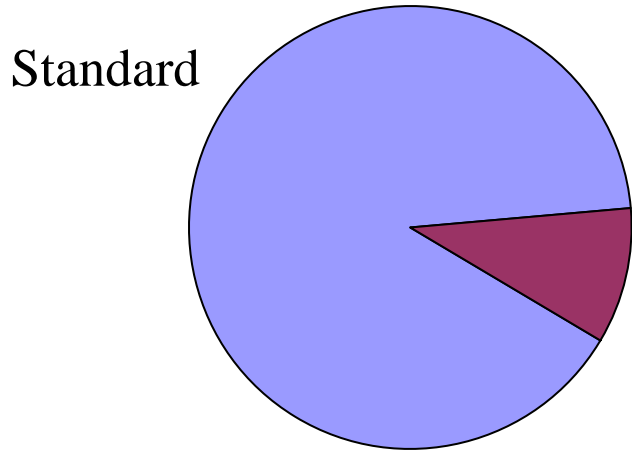


North American Market information: Emulsion Polymer Volumes Est. – by End Use



Paper is second largest end use market for emulsion polymers (20%)

Global Paper Market:

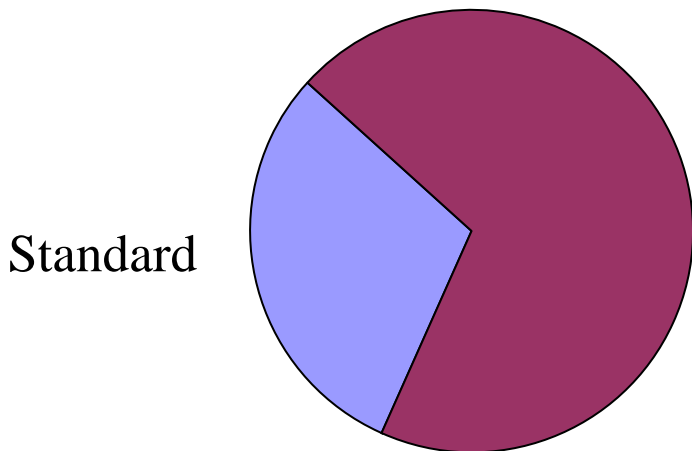


Estimates vary, but only ~10% of paper grades can be considered "specialties"

Specialty

Our business strategy & unique polymer products provide a natural fit with Specialty Paper manufacturers

Air Products Polymers' Paper Market:



However, over 70% of our paper segment volume is used in specialty applications

Specialty

Standard

Polymerization



MONOMER

Liquid

Solid

Gas

POLYMER

Large Molecule

Glassy

Rubbery

Emulsion Polymers

- **Medium / carrier is water**
 - **Reaction carried out in water**
- **Polymer suspended / dispersed in water**
 - **Not true solution**
 - **Most emulsion polymers are not water soluble**
- **Environmentally friendly**
 - **Low VOC**
 - **Most new products**
 - **Virtually formaldehyde free**
 - **APE free**
- **Broad ability to tailor polymer to meet end use requirements**

What is a Polymer Emulsion ?

Appearance:

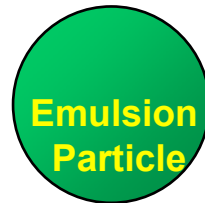
- White liquid; solid particles are dispersed in an aqueous medium

Dispersions particles:

diameter: $\sim 0,20 \mu\text{m}$

surface: $\sim 0,50 \mu\text{m}^2$

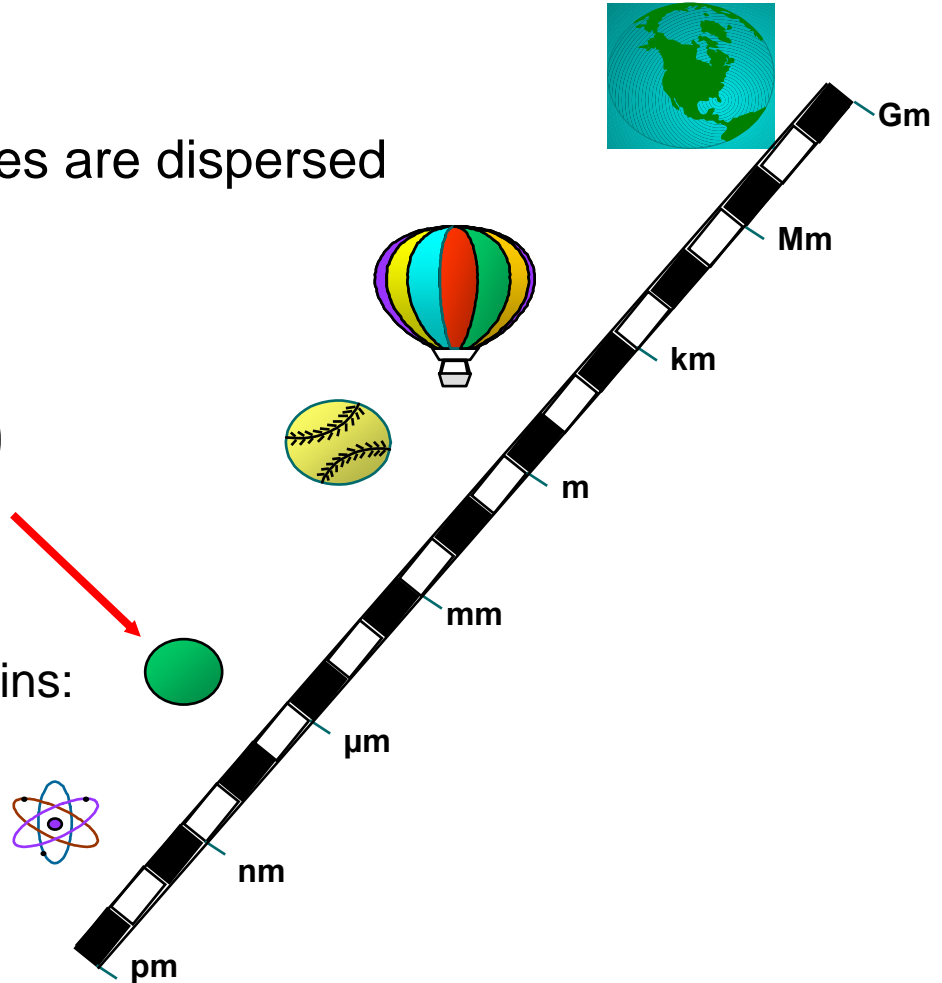
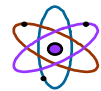
volume: $\sim 0,03 \mu\text{m}^3$



1liter (50% solids content) contains:

number of particles: $\sim 1,5 \times 10^{16}$

total surface area: $\sim 7500 \text{ m}^2$



Surface area in 1liter is > than a soccer field and offers incredible potential for functionalizing coating formulations !!

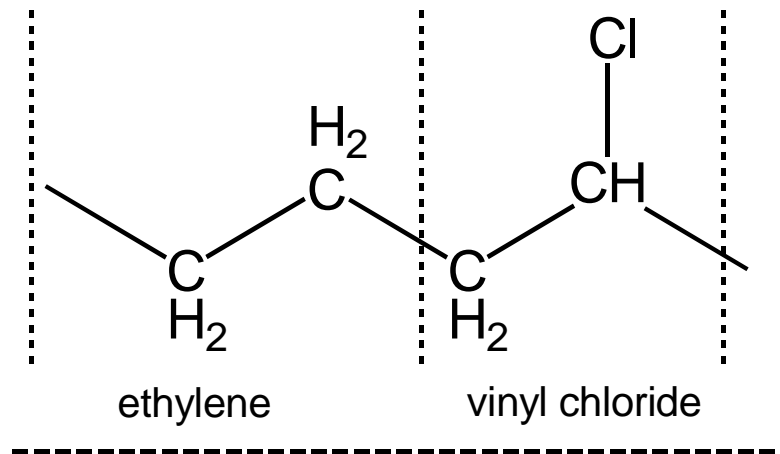
Emulsion Selection Criteria

- **Polymer type**
 - Homopolymer vs. Copolymer
 - Inherent properties of polymer
 - Hydrophobic vs. Hydrophilic
 - Flame retardancy
 - Physical/ Mechanical properties
 - Tg – Flexibility or stiffness
 - MW – Strength
 - Amorphous or semi-crystalline
- **Surfactant / protective colloid**
 - Suspend polymer particle in water
 - Control particle size / distribution
 - Rheology
 - Other – solvent resistance, particle charge
- **Functional monomers**
 - Polymerized into backbone of polymer
 - Impart cohesive strength, additional stability, other
- **Other additives**
 - Defoamers – control foam
 - Buffer – adjust / control pH

A Few Examples

Ethylene - Vinyl Chloride Copolymers (EVCL)

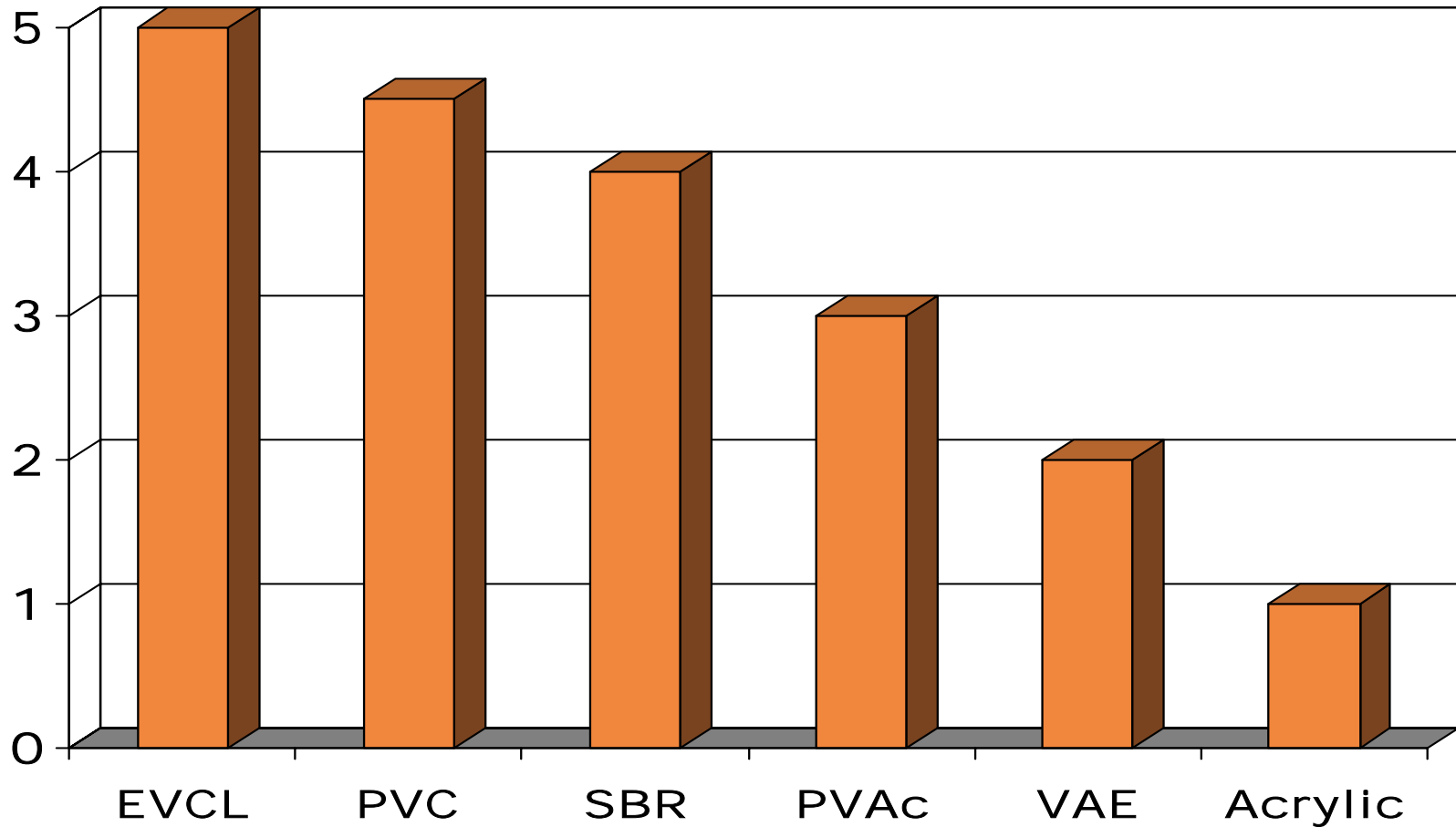
Ethylene - Vinyl Chloride



Flexibility
Softness

Hydrophobicity
Flame Retardancy
Moisture Vapor Barrier Properties
Stiffness
Grease / Oil Resistance
Scuff Resistance

Relative Flame Retardancy of Various Polymers



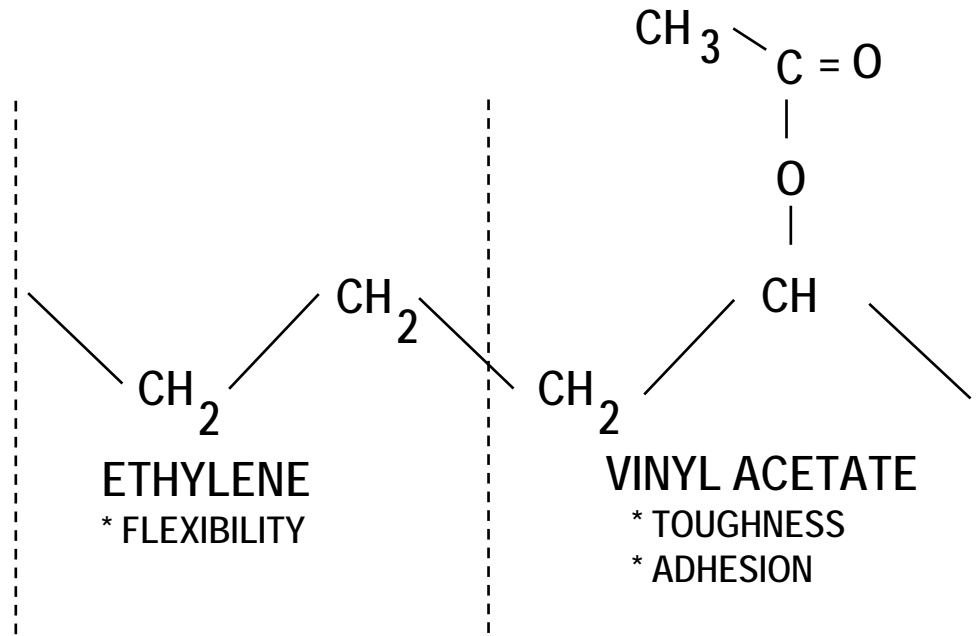
EVCL Polymer Attributes

- **Flame Retardancy**
- **Abrasion Resistance**
- **Moderate MVTR**
- **Grease and Oil Resistance**
- **Solvent Resistance**
- **Methanol Compatibility**
- **Choice of Stiffness or Flexibility**
- **“Self-Plasticized”**

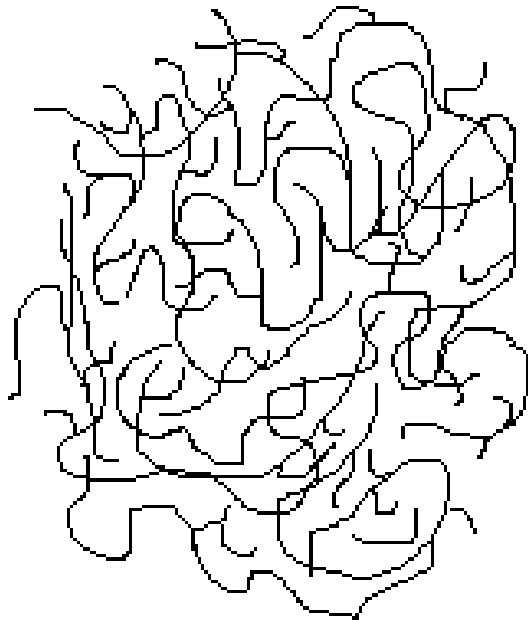
EVCL Copolymers: Typical Applications

- **Air Filter**
- **Oil Filter**
- **Wallpaper saturants**
- **Hi-Loft Substrates**
- **Fire Retardant Fabrics**
- **Medical Disposables**
- **Roofing substrate**
- **Vertical Blinds**
- **Heat sealable applications**

Vinyl Acetate-Ethylene Copolymer (VAE)



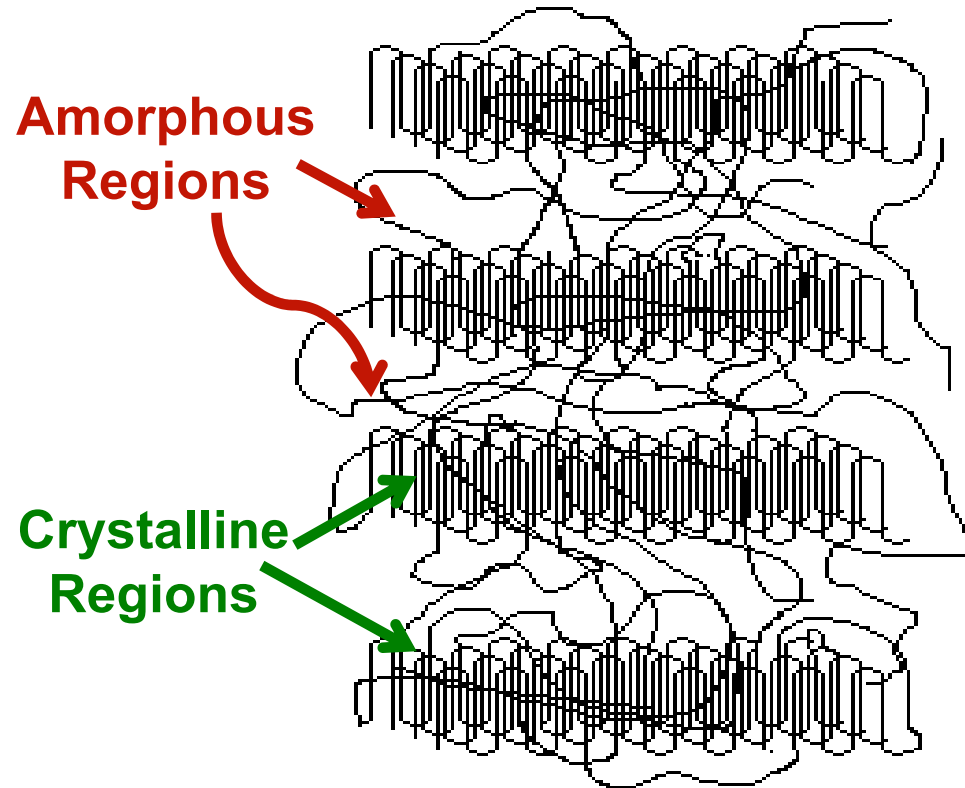
Amorphous Architecture



- **Polymer chains:**
 - Entangled
 - Randomly arranged
- T_g

Semi-Crystalline Architecture

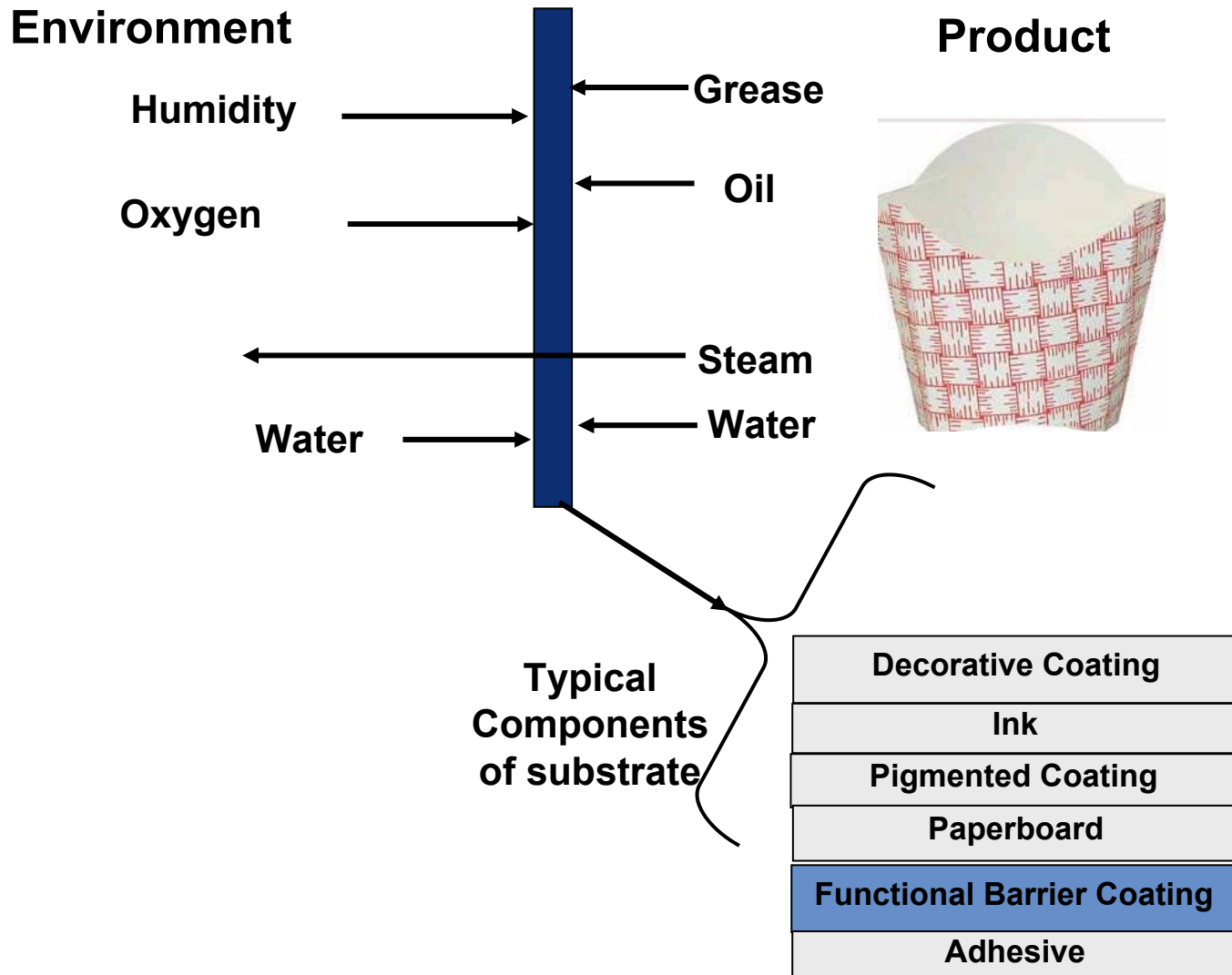
- Random & ordered polymer chains
- T_g
- Heat of fusion (ΔH_f)
 - How much crystallinity
- Melting point (T_m)
 - Crystal perfection



Crystalline VAE Features

- **Low Tg, but non-tacky films**
- **Controlled adhesion vs. Temperature (Heat Seal)**
- **Unique mechanical properties**
- **Wax-like**
- **Low surface energy**
- **Low specific gravity**
- **Hydrophobic**
- **Oleophobic**
- **Permeation Resistance**

Functional Coatings



Composition of Functional Coatings

- **Chemistry**

- **Fluorochemical**
- **Wax**
- **PVDC**
- **Extrusion Coatings – PE / PET**
- **Aqueous Barrier Coatings**
- **Other**

- **Selection Criteria**

- **Requirements of grade – OGR, MVTR, FDA etc**
- **Application method**
 - **On machine vs. Off Machine**
- **Economics**



End Uses: Oil & Grease Resistance



**Bags and
Wrapping Papers**

**Folding
Cartons**

**Food Service &
Convenience
Packaging**

**Non-Food
Applications**

**Pet Food
Fast Food
Microwave Popcorn
Cookies and Bakery
Sandwich Wrappers
Pre-packed food
Cement Bags
other Multi Wall Bags**

**Detergent Boxes
Frozen foods
Wet food
Dairy products
Bakery
Pet food
Pizza boxes
Cake boxes
Milk, Juices
PE-coated board**

**Clam shells
French fry boxes
Ovenable trays
Plates
Drinking cups
Take out containers
Molded products**

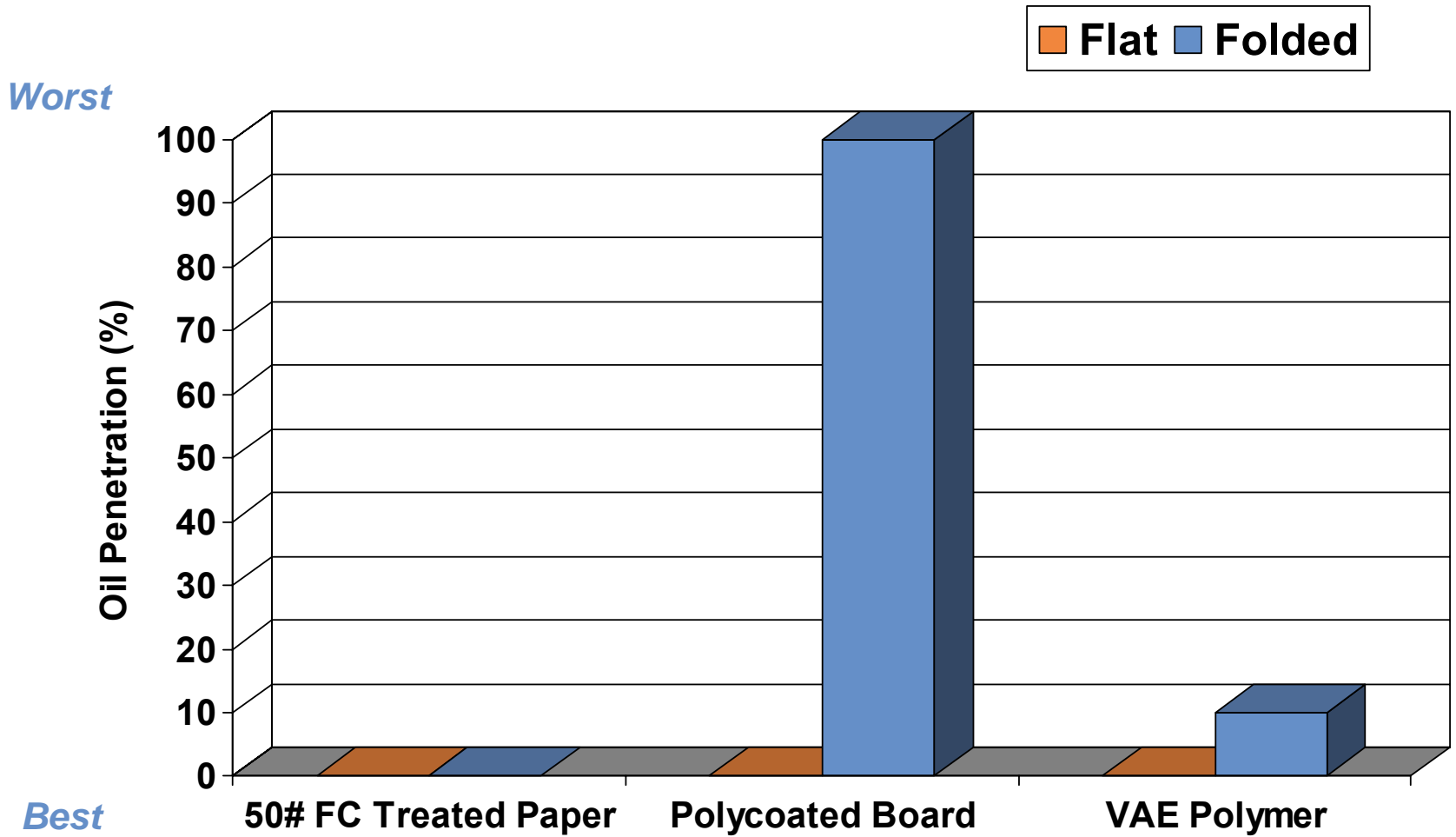
**Liner Board
Machine parts
Detergent box
PE coated Board
Specialty Papers
(carbonless forms)
Industrial &
Protective Packaging**



Coatings for Grease and Oil Resistant Packaging

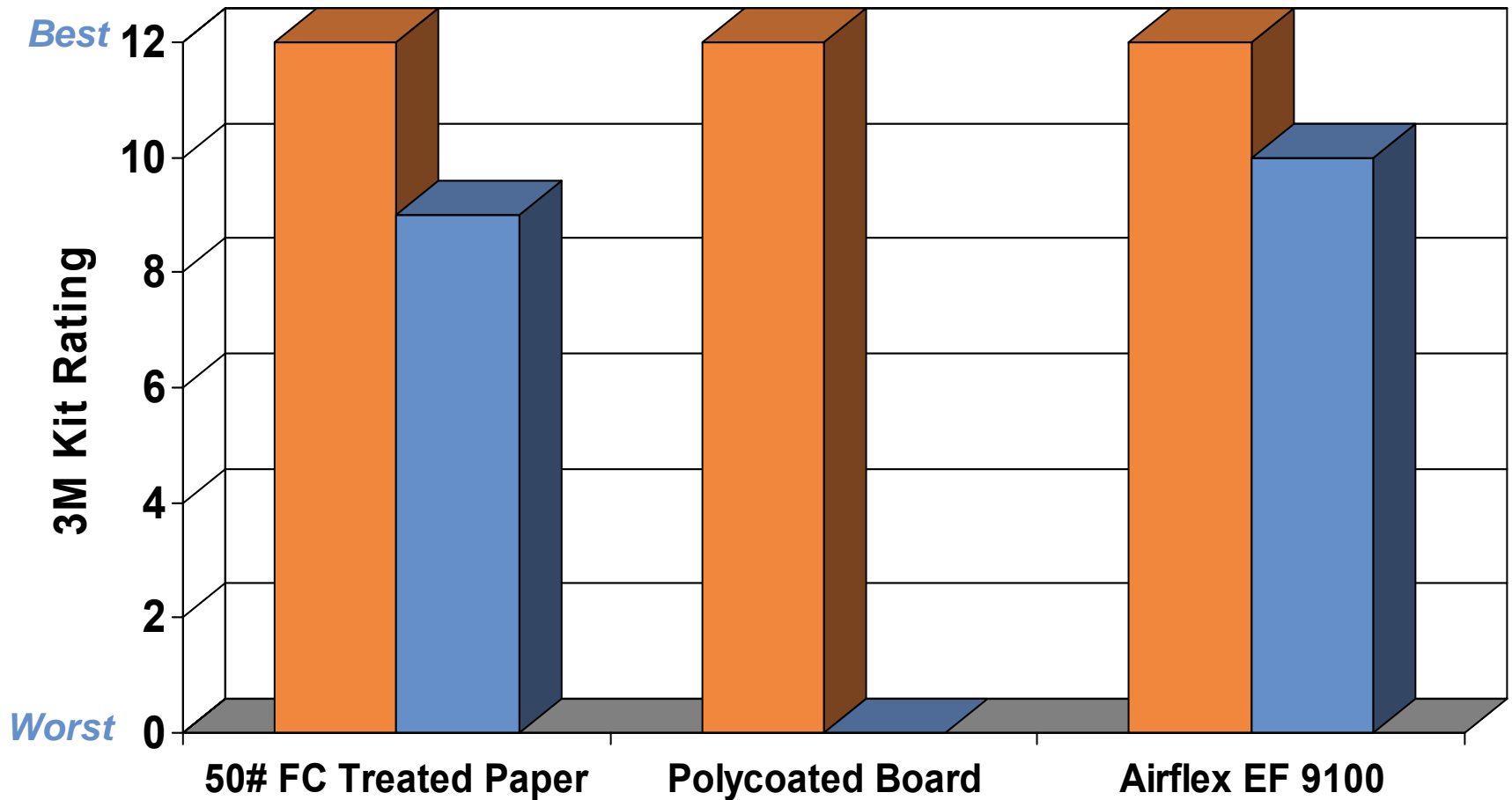
- **Coating types commonly used**
 - **Fluorochemicals**
 - **Waxes**
 - **Aqueous Barrier Coatings**
 - **Extrusion Coatings**
- **Coating Selection Criteria**
 - **Degree of Performance Needed**
 - **Fast food vs. Pet Food**
 - **Flat vs. Folded Performance**
 - **FDA Considerations**
 - **Cost in Use**
 - **Repulpability**
 - **Many others**

Hot Oil Test



3M Kit Results

(TAPPI UM 559 pm-96)



VAE Polymer Benefits vs. Other Technologies

- **Vs. Fluorochemicals**
 - **Economical**
 - **Environmentally Friendly**
- **Vs. Water Based Coatings**
 - **Excellent performance at crease \ score lines**
 - **Multiple coating methods**
 - **Non blocking**
- **Vs. Wax or Polyethylene**
 - **Economic savings in total system**
 - **Repulpable**

Conclusions

- **Coatings with specific functionality allow the development of a broad spectrum of specialty paper grades**
- **Selection of coating is dependent on many factors**
 - **Requirements of grade**
 - **FDA considerations**
 - **Economics**
 - **Coating Application Requirements**
 - **Environmental Considerations**
- **Specialty paper manufacturers and raw material suppliers need to continue to work together to expand the possible end uses for specialty paper grades**